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A Microscopic Study of the Bursa Copulatrix of *Gonepteryx* (Lepidoptera: Pieridae)

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*Gonepteryx*속(인시목 : 흰나비과) 교미낭의 미세구조에 관한 비교분석

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적 요

흰나비과중 *Gonepteryx*속의 6종에 대한 교미낭을 해부 및 주사전자현미경으로 관찰하여 종간의 형태를 비교분석 하였다. 흰나비과의 다른 속에서처럼 이 속의 교미낭도 *ductus bursa*, *corpus bursa* 그리고 *appendix bursa*의 세 부분으로 뚜렷이 구분되었으며, *corpus bursa*의 형태는 종에 따라 그 차이가 비교적 뚜렷하였으나 *signum*은 모두 *ribbon*모양으로 속내에서 매우 안정된 형태를 보였다. *Signum*주위 내벽에는 동심원상으로 많은 주름이 발달해 있었으며 그곳에는 내벽돌기가 없었고 맞은편에 광범하게 분포하였다. 내벽돌기는 대부분 방추형이었으며 교미낭의 형태와 내벽돌기의 상태로 고려했을때 *G. aspasia*와 *G. taiwana*가 속내에서 가장 유사한 종들로 인식되었다.

Key words: *Gonepteryx*, bursa copulatrix, morphology.

INTRODUCTION

Species of *Gonepteryx* have yellow body color and apices of forewings are sharp. They belong to Coliadinae and contain eight or more number of species. They distribute in the Paleartic region (Smart, 1978). From the Korean peninsula, only two species, *G. aspasia* and *G. rhamni* have been recorded (Kim, 1976; Lee, 1982; Shin, 1989). The studies on the morphology of *Gonepteryx* have been performed by many entomologists (Yata, 1981; Ferris et al., 1983; Hancock, 1985). The studies on Korean *Gonepteryx* have been morphologically and phylogenetically performed with other pierid genera (Cheong, et al., 1988, 1989, 1990). In many cases, classifications of lepidoptera have depended on the characters of wings and male genitalia, and the importance of female genitalia, especially that of bursa copulatrix has not been emphasized. In fact, there are limited references on the bursa copulatrix.

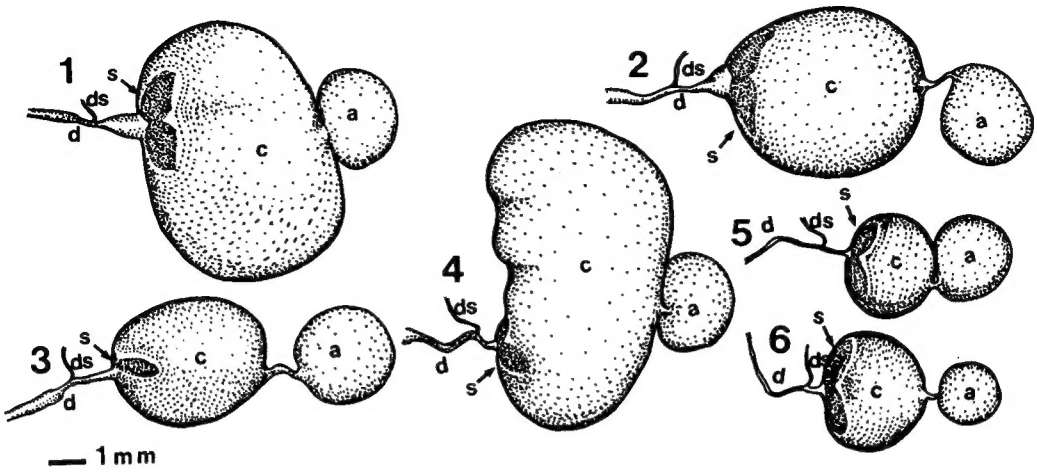
All of the species of *Gonepteryx* employed in this study have similar wing patterns, and additional information as well as external morphology will be helpful to the classification of this genus. Therefore, in this paper, we compared structures of bursae copulatrix of *Gonepteryx* species in detail from this viewpoint. We found similarities among species on the basis of the morphology of bursae copulatrix and considered the classificational value of characters of this organ.

MATERIALS AND METHODS

Dried specimens of six *Gonepteryx* species were supplied from Greece, Netherlands, Spain, Austria, France, England, Russia, Taiwan and Japan. For the examination of the morphological variation, at least five female individuals for each species were used. Abdomens were bolied in 10% KOH for ten minutes, and they were dissected in saline solution. Materials were observed under a stereoscopic microscope. Corpus bursae were turned inside out for the comparison of the fine structure and then dehydrated in a graded ethanol series. The samples were coated with 200Å gold ion and examined with ISI-SS 130 SEM.

RESULTS

Bursae copulatrix of *Gonepteryx* species were consisted of ductus bursae, corpus bursae and appendix bursae. Morphological variations among individuals were not serious. As bursae copulatrix of most genera of Pieridae, appendix bursae were also developed in this genus. Generally, ductus bursae were slender and ductus seminalis were diverged on them near corpus bursae. The shapes of corpus bursae were spherical or oval except to *Gonepteryx farinosa*, and length of appendix bursae exceed 1/3 of corpus bursae. They have cervical signa in corpus bursae and the signa were strong, symmetric and shaped like ribbons. On innersurfaces of corpus bursae around signa, many of folds were strongly developed and there was no innersurface processes near signa. Most of innersurface processes were distributed on opposite sides of signa respectively and the processes shaped like spindles.



Figs. 1-1∼6. The bursa copulatrix of *Gonepteryx*.
1; *G. rhamni; 2; G. amintha; 3; G. cleopatra; 4; G. farinosa; 5; G. aspasia; 6; G. taiwana.*
d: ductus bursa ds: ductus seminalis c: corpus bursa a: appendix bursa s: signum

G. rhamni (Figs. 1-1, 2-1, 3-1)

The corpus bursa wide horizontally, the length of the appendix bursa about 1/3 of the corpus bursa, the average length of ductus bursae 2.7mm. The signum at the neck, with a constrict and thick ribbon-like signum. Tongue-like innersurface processes distributed and basal ridges (arrows) developed.

G. amintha (Figs. 1-2, 2-2, 3-2)

The corpus bursa spherical, the length of the appendix bursa about 1/2 of the corpus bursa, the average length of ductus bursae 3.2mm. The signum at the neck, with a constrict and thick ribbon-like signum. Tongue-like innersurface processes distributed and basal ridges weakly developed.

G. cleopatra (Figs. 1-3, 2-3, 3-3)

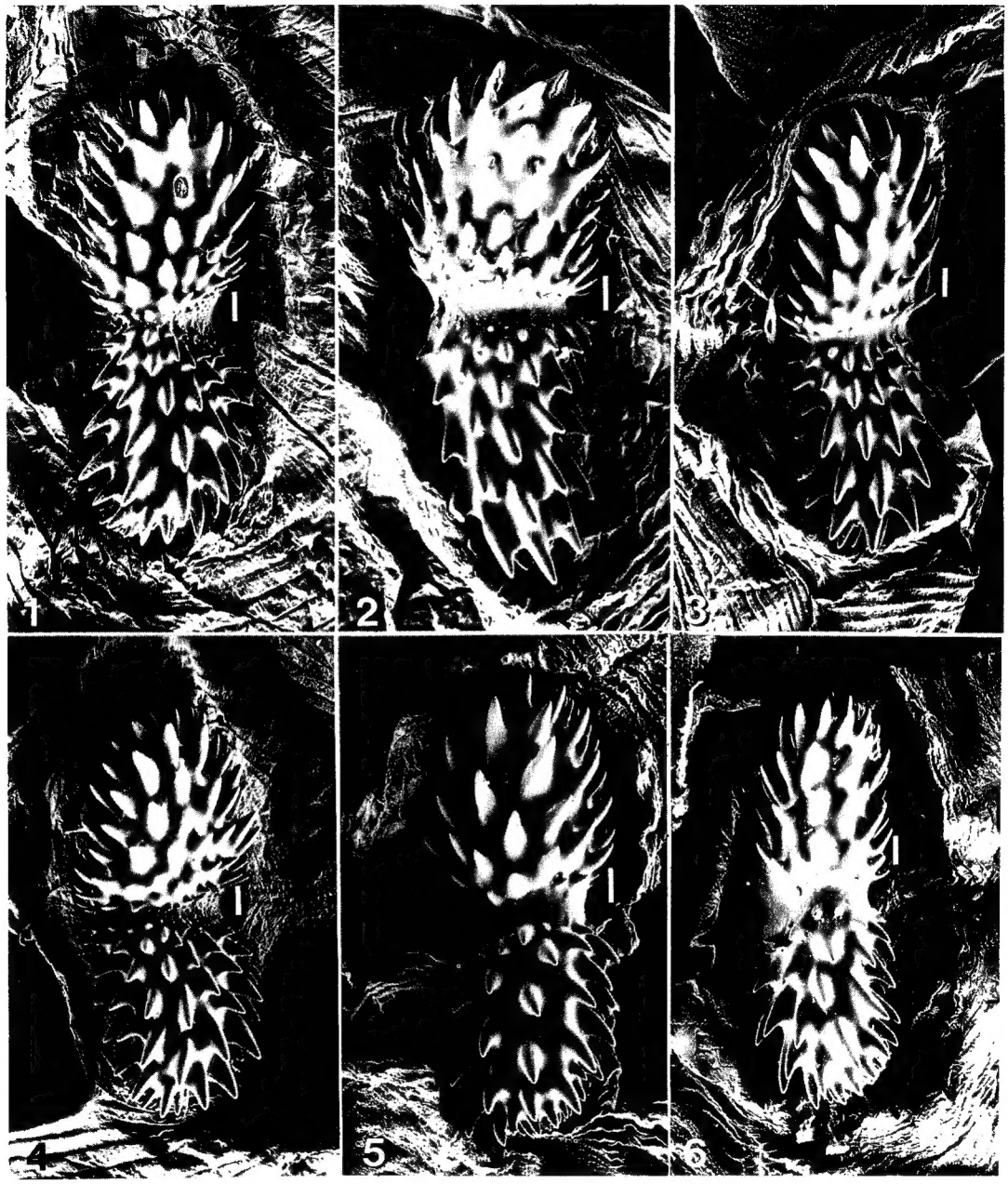
The corpus bursa spherical, the length of the appendix bursa about 3/4 of the corpus bursa, the average length of ductus bursae 2.9mm. The signum at the neck, with a constrict and thick ribbon-like signum. Spindle-like innersurface processes distributed and basal ridges weakly developed.

G. farinosa (Figs. 1-4, 2-4, 3-4)

The corpus bursa swelled dorsally, the length of the appendix bursa about 1/3 of the corpus bursa, the average length of ductus bursae 2.7mm. The signum at the neck, with a constrict and thick ribbon-like signum. Short and sharp tongue-like innersurface processes distributed and basal ridges (arrows) developed.

G. aspasia (Figs. 1-5, 2-5, 3-5)

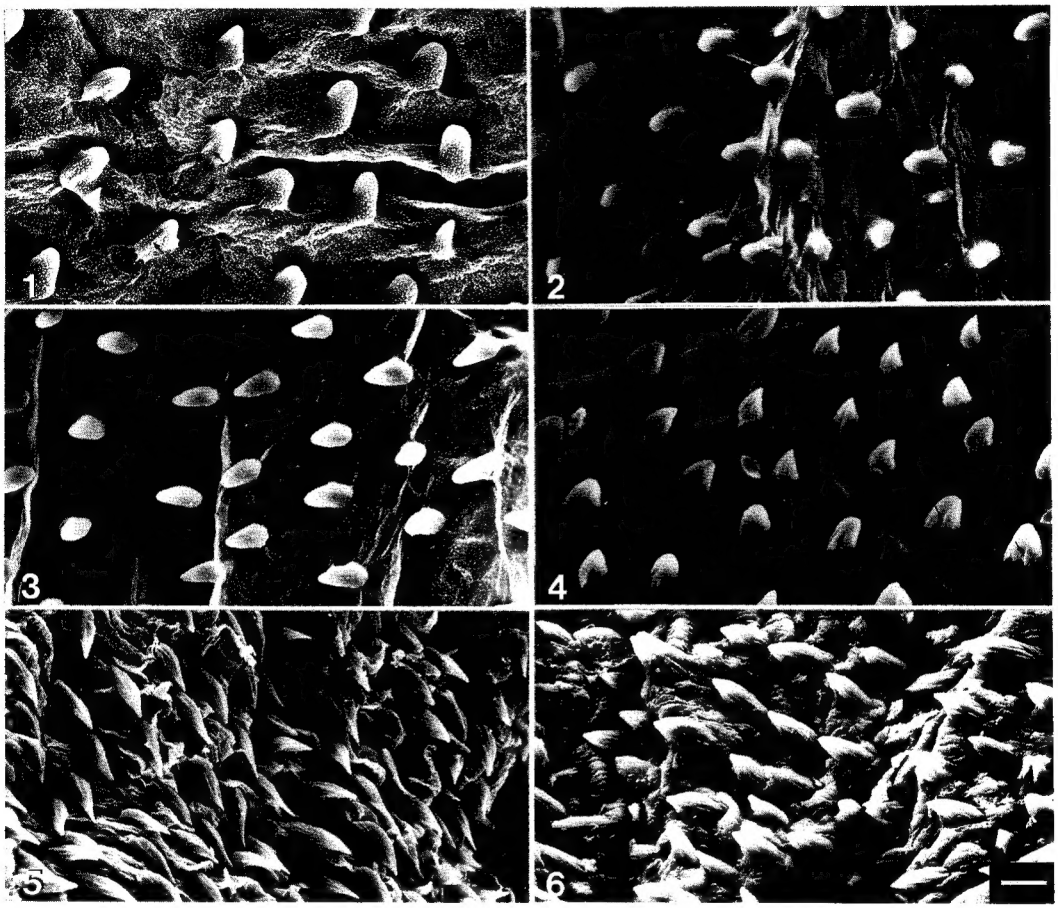
The corpus bursa spherical, the length of the appendix bursa about 1/2 of the corpus bursa, the average length of the ductus bursae 3.2 mm. The signum at the neck, with a constrict and thick ribbon-like signum. Sharp spindle-like innersurface processes densely distributed and basal ridges stronly developed.



Figs. 2-1~6. The signa of *Gonepteryx*.
1; G. rhamni; 2; G. amintha; 3; G. cleopatra; 4; G. farinosa; 5; G. aspasia; 6; G. taiwana. *scales: 100μm

G. taiwana (Figs. 1-6, 2-6, 3-6)

The corpus bursa spherical, the length of the appendix bursa about 1/2 of the corpus bursa, the average length of ductus bursae 3.2mm. The signum at the neck, with a constrict and thick ribbon-like signum. Sharp spindle-like innersurface processes densely distributed and basal ridges strongly developed.



Figs. 3-1∼6. The innersurface processes of *Gonepteryx*.
1; G. rhamni; 2; G. amintha; 3; G. cleopatra; 4; G. farinosa; 5; G. aspasia; 6; G. taiwana. *scale: 10 μm

DISCUSSION

The bursa copulatrix is an organ which forms the shape of spermatophore and holds it. Although the bursa copulatrix is not a sclerotized organ, it stands against drying and boiling. According to the study of Cheong et al. (1990), appendix bursa of genera of Pieridae are well developed and those of *Gonepteryx* are the same. The fuction of appendix bursa has not been cleared, however, it had been cleared by Outram (1971) there is no secretary gland in bursa copulatrix. And the function of appendix bursae is considered as the secondary preservation of free sperms escaped from spermatophors. The diverging points of ductus seminalis of this genus are near entrances of corpus bursae, and this condition gives an advantage to free sperms. They need not to travel long distance to the ductus seminalis. In general, genus *Pieris* has many of plesiomorphic characters of bursa copulatrix by Cheong et al. (1990), and ductus bursae of *Gonepteryx* is considerably apomorphic compare to *Pieris*. Shapes of bursae copulatrix of *G. aspasia* and *G. taiwana* are resemble and sizes are almost same. But corpus bursae of *G. rhamni* and *G. farinosa* are reversely

swelled each other. Probably, spermatophores of them are large and in especial, that of *G. farinosa* is unique. Cervical signa scrap and tear spermatophores at entrances of bursae copulatrix and free sperms will be directly introduce to ductus bursae. In the dorsal lumen of the signum, muscles are inserted and scrap the spermatophore by the contraction of the muscles and abdomen (Chapman, 1982). In this genus, free leaves of signa are strongly developed in lumens of corpus bursae and strong spines of signa gives the efficiency to the scraping role. Moreover, folds around signa may give the elasticity to corpus bursae when the muscles contract and signa scrap. Considering from plate signa and weakly developed folds of *Pieris*, these conditions are also apomorphic. The role of innersurface processes is regarded as holding rather than scraping the spermatophore. Shapes of innersurface processes of *G. amintha* are similar to those of *G. cleopatra*, and *G. aspasia* has similar innersurface processes with *G. taiwana*. Therefore, *G. aspasia* and *G. taiwana* are regarded as the most similar species among the six species considering all of conditions of bursa copulatrix. And the similarity of the bursa copulatrix of *Gonepteryx* nearly correspond to that of wings.

Although shapes of signa of this genus are too similar to distinguish species, the signa are separated from those of other genera. Shapes of bursa copulatrix and conditions of innersurface processes are distinct to species. In conclusion, we suggest that characters of the bursa copulatrix are considerably valuable to classify Pieridae, and the characters are diagnostic to the classification of the genus level.

ABSTRACT

Bursae copulatrix of six species of *Gonepteryx* were morphologically compared using a steroscopic microscope and a scaning electron microscope. As other genera of Pieridae, appendix bursae were developed in this genus and the shapes of the bursae copulatrix were different to species. However, shapes of signa were stable and were not distinct to species. On innersurfaces around ribbon-like signa, many folds were developed and most of innersurface processes were widely distributed on the opposite side of signa. Most of innersurface processes were spindle-like and basal ridges were developed. *G. aspasia* and *G. taiwana* were recognized as the most similar species in *Gonepteryx* considering shapes of bursae copulatrix and the condition of innersurface processes.

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